EFFECTS OF SODIUM CITRATE AND SEASON ON AMBIENT CHEMICAL PROPERTIES OF *"DENDERU"* A NIGERIAN TRADITIONAL MEAT PRODUCT

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ABSTRACT
Five (5.0) kg of beef was obtained from Wudil market and divided into five portions. Four portions were treated by dipping for one hour in 0.2% clove (CLA), 0.2% sodium citrate (SCA), 0.2% clove and sodium citrate (SCB) and another in a combination of 0.25% of sodium citrate and clove (SCC), and the remaining portion served as the control (LCS). The portions were drained, rubbed with spices, cooked overnight in an earthenware pot inside a pit with glowing charcoal. The samples were removed, cooled and wrapped in brown papers. This experiment was carried out during the rainy and dry seasons. Samples were kept at ambient temperature and were examined for chemical weekly for a period of four weeks. For samples produced during rainy season there was increase in pH value during storage and for samples produced during dry season there was decrease in pH value during storage. The Free Fatty acid (FFA) values increased generally during storage for the samples produced during both rainy and dry seasons. The results indicate the sample treated with 0.2% sodium citrate and clove had lower FFA values. The Thiobarbituric acid (TBA) values of all samples increased throughout the storage period with the untreated control sample having higher values. The peroxide values increased for both samples throughout the storage period with the untreated control having higher values though; none of the samples exceeded the maximum limit recommended by codex (12.5 millieq O_2/kg). From the result of this work it was observed that the treatment that has greater effect for both rainy and dry season is a combination of 0.25% sodium citrate and 0.25% clove. Storage of denderu samples is better during dry season because of low humidity and higher temperature.

Key words: Denderu, Meat, Clove, Sodium citrate, Chemical properties.

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INTRODUCTION

"Denderu" is spiced, barbecued mutton, beef or poultry meat that is roasted overnight in an earthenware pot in a pit over a glowing fire. It is very common in Borno and Yobe states, where the Kanuris and Shuwa Arab tribes are located. It has stimulating and appetizing flavours and is therefore served on special occasions such as weddings, naming ceremonies and arrival of "August" visitors (Negbenebor*et al.*, 2001a). Ueda *et al.* (1982) examined the ethanolic extracts of spices and herbs for inhibiting of bacteria and fungi at different pHs. Clove extract showed remarkable antibacterial activity against all organisms tested and oregano and cinnamon exhibited wide inhibitory spectrum. Sodium citrate and its acid form, citric acid, have been widely used in the food industry to control pH of the foods and as a synergistic antioxidant (Anderson and Marshall, 1990), and also as a carcass decontaminant (Acuff, 1991). Recent studies demonstrated the possible use of sodium citrate as a meat tenderizer (Sitz*et al.*, 2005). Little or no information is available on combined use of clove and sodium citrate. Their combined use may be beneficial to the meat industry.

MATERIALS AND METHODS

Sample Acquisition

Meat (Beef) used for this study was purchased from Wudil Market and it was then transported to Department of Food Science and

Technology, Kano University of Science and Technology Wudil for processing and analysis. The other ingredients used were purchased from LahadinMakole market in Kano State. Reagents and equipments for analysis were obtained from Food Science and Technology Laboratory, Kano University of Science and Technology, Wudil.

Sample Preparation

The temperature and relative humidity for both seasons were recorded as dry season temperature of 37- 21^{o}C and Relative humidity of 30%, while for rainy season the temperature and relative humidity were 35 - 23^{o}C and 80%, respectively. The meat was washed and cut into five portions each weighing one kg. Each portion was then cut into smaller pieces 3cm by 3cm. The clove used was ground and autoclaved.

Experimental Design

The samples were prepared as presented in Table 1. Ingredients were formulated and ground using hammer mill with 1.0 mm sieve size. Ground spices were wrapped in brown paper, autoclaved at 121.1°C for 15 minutes at a pressure of 15 psi and cooled to ambient temperature. The meat samples were rubbed with the formulated ingredients separately and reweighed. The method of "Denderu" production was as reported by Negbenebor*et al*. (2001a). A pit of 47.8cm diameter and 60.6cm depth was dug. An earthenware pot with the bottom removed was inverted and inserted into the pit (Plate). The diameter of the pot and thehole at the bottom were measured. The space between the pot and the pit was filled with the dugout sand. A glowing fire was made inside the pot using firewood from *Balanitesaegyptica* (Aduwa) and *Anogeissusleicarpus* (Marke) species.

The meat samples were arranged on pieces of earthenware pot and placed on top of the flame inside the pot. The pot temperature was measured. The top of the pot was covered with laminated paper, a piece of calabash, polyethylene and a tray before finally adding some sand to bury the pot. It was allowed to roast overnight, cooled, wrapped in brown paper and stored at ambient temperature. It was examined chemically on the first day and weekly for three weeks.

Thiobarbituric acid determination

The 2- thiobarbituric acid (TBA) test for rancidity was carried out by the water extraction method as described by Tarladgis*et al.* (1964). TBA reagent (0.2883 g) was dissolved in one litre of distilled water to obtain 0.02M. Ten grams of the meat sample was mixed with 50 m1 of distilled water and blended for at least two minutes and the slurry was transferred quantitatively into a beaker with an additional 50 ml of distilled water. It was then filtered into a 100-ml volumetric flask and the volume was made up to mark with distilled water used to wash the filter paper. Five ml of the clear filtrate was pipetted into a diluent bottle and five ml of TBA reagent was added. The blank was also prepared containing 5 ml of distilled water and 5 ml of reagent. The samples were boiled in a water bath for 40 minutes at 100^{o}C; the absorbance was read at the wavelength of 532 nm in a spectrophotometer against a TBA reagent blank. To calculate the TBA value the optical density expressed as (OD) was multiplied by 1.44

TBA value = O.D value x 1.44

pH determination

Five grams of the ground meat sample was mixed thoroughly in 20 m1 of distilled water. The pH meter was adjusted with buffer 4.0 and 7.0 The pH of the sample were measure using pH electrode. (Pearson, 1991)

Free fatty acid

Lipid from 10.0 g samples was extracted with hexane until the thimble showed no appearance of oil. The solvent was distilled off; the oil was weighed and kept for further analysis.

The acid value and free fatty acid content were determined by AOAC method 940.28 (AOAC, 2000). The oil sample (0.2 g) was dissolved in 10 ml ethanol and titrated with 0.1M KOH solution using phenolphthalein indicator until pink colour disappeared. The acid value and the percentage fatty acid were calculated from the expression below:

$$\text{Acid Value} = \frac{56 \text{ X molarity of the KOH}}{\text{weight of the oil}}$$

%free fatty acid as oleic acid = 0.503 x acid value

Peroxide value

The peroxide value was determined according to the method described by AOAC (1990). Fat extracted from the sample (5.0 g) was weighed into a 250 ml conical flask, dissolved with 30 ml solvent mixture containing 12 ml chloroform and 18 ml glacial acetic acid. Saturated aqueous potassium iodide solution (0.5 ml) was added; the flask was stoppered and allowed to stand for one minute. Thereafter, 30 ml of distilled water was added and the solution was titrated against 0.1M sodium thiosulphate solution until the yellow colour had almost disappeared. At this point, starch solution (0.5 ml) was added and the titration continued until the blue-black colour disappeared. The same procedure was carried out for a 'blank' determination, where the oil sample was excluded. The peroxide value expressed as (PV) was calculated from the expression below:

$$\text{P . V (meq/ kg)} = \frac{(\text{S} - \text{B}) \text{ x M x } 1000}{\text{weight of sample(g)}}$$

where;

meq/kg = milliequivalent peroxide/kg sample

S =Titre value (ml) of sodium thiosulphate for sample

B = Titre value (ml) of sodium thiosulphate for blank,

M = Molarity of sodium thiosulphate solution

Table 4.2 shows the result of the pH of the samples produced during rainy season from the day of production to the third week of storage. In week 0 the pH values were 6.49, 6.52, 6.70, 6.15 and 6.63 for samples SCA, CLA, SCB, SCC and LCS, respectively.

As the storage time progressed there was significant increase (P<0.005) in the pH values. After the third week the pH values were found to be 7.44, 7.55, 7.43, 6.93 and 7.33 for samples SCA, CLA, SCB, SCC and LCS, respectively. For the samples produced during dry season and stored for the period of three weeks. The pH generally decreased with storage time, in week 0 the highest pH was that from sample SCB 6.96 and the lowest sample was LCS 6.13, at the end of the storage time the highest pH was that of sample CLA 6.35 and the lowest sample SCB 6.14.

The pH of the samples produced during the rainy season (Table 4.2) were 6.49, 6.52, 6.70, 6.15 and 6.63 for samples SCA, CLA, SCB, SCC and LCS, respectively. The pH of samples SCA and CLA were not significantly different (P >0.05). The pH values decreased in the first week to 6.14, 6.15, 6.23 5.88 and 6.11 for samples SCA, CLA, SCB, SCC and LCS, respectively. The values then increased up to the third week of storage. Sample treated with a combination of 0.2% clove and 0.2% sodium citrate had higher pH values (P< 0.05) on week 0 when compared to other samples during rainy season storage. There were increases in pH values in all samples irrespective of treatment after three weeks of storage at ambient temperature during rainy season storage. This could be as a result of high humidity and water uptake by the samples.

The pH of the samples produced during the dry season were 6.89, 6.52, 6.96, 6.19 and 6.13 for samples SCA, CLA. SCB, SCC and LCS respectively which differ significantly (P< 0.05) between the samples. In general the samples pH decreased up to the third week for all the samples pH or product acidity is involved in a variety of aspects important to the manufacture of processed meats. Hydrogen ion concentration influences the technological, antimicrobial, and flavoring properties of fresh and processed meats.

Changes in the pH of processed meat products affect protein extraction and water holding capacity (WHC). This in turn influences product binding, texture, color, and microbial spoilage. An increase in pH above 5.0-5.5 results in an increased retention of water by the meat due to changes in the electrical charges of the muscle proteins as the pH is increased above the isoelectric point. The dominance of negative charges at higher pH values results in increased electrostatic repulsion which increases protein solubility and water retention. As the pH of the meat decreases towards the isoelectric point of the proteins, their solubility decreases.

Free Fatty Acid of the "Denderu" Samples Produced During Rainy and Dry Seasons

Table 4.3 shows the result of the free fatty acid (FFA) composition of the samples for the period of three week storage. The free fatty acid value increased with storage time. On the 0 week of storage, sample SCA had the highest value of 0.286 meq/kg and the least value was recorded for sample CLA 0.097 meq/kg, after three weeks of storage; Sample SCC had the highest value of 0.957 meq/kg while sample CLA (0.2% Clove) had the least value of 0.321 meq/kg. For the samples produced during dry season and stored for the period of three weeks, the FFA values during the 0 week were 0.112, 0.168, 0.113, 0.141 and 0.199 meq/g for samples SCA, CLA, SCB, SCC and LCS, respectively. The FFA values increased with storage time for all samples. At the end of the three week FFA had reached 2.81, 2.155, 1.039, 0.563 and 2.970 meq/g for samples SCA, CLA, SCB, SCC and LCS, respectively.

Free fatty acids are the products of enzymatic or microbial degradation of lipids. Determination of Free fatty acids gives information about stability of fat during storage. The FFA of the samples produced during the rainy season (Table 4.3) in the 0 week were 0.286, 0.097, 0.115, 0.207 and 0.115 meq/kg for samples SCA, CLA, SCB, SCC and LCS, respectively.

The FFA values increased significantly up to the third week of storage. It was observed that sample CLA which was the sample that was treated with 0.2% clove differed significantly from the other samples ($P< 0.05$). The FFA values for the samples produced during dry season were found to be 0.112, 0.168, 0.113, 0.141 and 0.199 meq/kg for samples SCA, CLA, SCB, SCC and LCS, respectively for the 0 week.

There was no significant difference ($P> 0.05$) observed. The FFA values increased from first week up to the third week where all the samples differ significantly ($P< 0.05$) from each other. The result indicated that the samples treated with 0.2% clove and a mixture of 0.2% clove and sodium citrate have lower FFA values for the two seasons, likewise samples treated with 0.2% sodium citrate and combination of 0.25% sodium citrate and clove were found to have lower FFA values for the samples produced during dry season. This is an indication that the treatment reduced the FFA production during storage. According to the regulation (EC) No 853/2004 of the European commission and of the council laying down specific hygiene rules for food of animal origin, the maximum permitted level of FFA in edible animal fat is 1.25% FFA as oleic acid. The samples produced during the dry season did not exceed this value up to the second week of storage. After the third week only samples SCB, and SCC did not exceed this value.

This suggests that the use of 0.2%, 0.25% sodium citrate and clove inhibited the rate of production of free fatty acid on "Denderu" samples. For the samples produced during rainy season, it can be observed that no sample exceed the maximum value of 1.25% up to the third week. There is significant difference ($P< 0.05$) in FFA between the samples stored during rainy and dry seasons. There is also significant difference between different weeks of storage of the samples. This is because the treatment cannot stop the production of free fatty acid but rather lower the production.

Free fatty acids are the products of enzymatic or microbial degradation of lipids and determination of FFA gives information about the stability of fat during storage (Das *et al.,* 2008). FFA formation is by hydrolysis reactions within lipids (Perkins, 2006) and their accumulation can be used as an indicator of lipid breakdown. Individual free fatty acids are also known to contribute flavours and aromas, not all of which are considered desirable in foods (Ledahudec and Pokorny, 1991), although the use of FFA as a food quality indicator is not recommended (Matthäus, 2006). Additionally, FFAs are more susceptible to oxidation than their esterified counterparts (Presswood, 2012). The free fatty acids of most of the samples were significantly lower than control (Non-treated) throughout the storage period, this result agreed with that reported by (Yavas and Bilgin 2010).

TBA Result of the "Denderu" Samples Produced During Rainy and Dry Season

Table 4.4 shows the result of the (Thio-barbituric acid) TBA analysis for the period of three week storage during rainy season. The TBA values increased with storage time with zero week having the highest and lowest values of 0.032 mg malonaldehyde/kg of meat for LCS and 0.018 mg malonaldehyde/kg for SCA, respectively. At the end of the storage period (three weeks) the following values were obtained 0.070, 0.094, 0.182, 0.252 and 0.522 mg malonaldehyde/kg for SCA, CLA, SCB, SCC and LCS, respectively.

For the samples produced during dry season and stored for the period of three weeks, the TBA values during the zero week were 0.021, 0.023, 0.026, 0.019 and 0.033 mg malon/kg sample for samples SCA, CLA, SCB, SCC and LCS, respectively. The TBA values increased with storage time up to the third week of storage when the values were 0.062, 0.056, 0.066, 0.057 and 0.067 mg malon/kg sample for samples SCA, CLA, SCB, SCC and LCS, respectively.

For TBA values of samples produced during rainy season (Table 4.4) in week zero, 0.018, 0.022, 0.029, 0.032 and 0.032 mg malonaldehyde/kg were recorded for samples SCA, CLA, SCB, SCC and LCS, respectively. There was little or no difference ($P<0.05$) in TBA values for all samples irrespective of treatment during the rainy season. The values increased throughout the period of storage of the samples. Following storage at ambient temperature, there were increases in TBA values for all samples, regardless of treatment, though the increase in rainy season was more than that obtained during the dry season. For the samples produced during dry season, in week zero, there was little or no difference ($P<0.05$) in TBA values for all samples irrespective of treatment during the dry season. The values ranged from 0.021, 0.023, 0.026, 0.019 and 0.033 (mg/kg of sample) for samples SCA, CLA, SCB, SCC and LCS, respectively. Following storage at ambient temperature, there were increases in TBA values for all samples, regardless of treatment. After three weeks sample treated with 0.2% clove had the least TBA value. Results indicate the ability of treatment to inhibit malonaldehyde production during storage of "Denderu" at ambient temperature. The work agrees with the report of Negbenebor*et al*., (2001a). Clove contains essential oil (eugenol) which inhibit malonaldehyde production during storage (Gulcin*et al.*, 2004).

The mean values of TBA numbers during the storage period were below the minimum threshold value i.e. 1 -2mg malonaldehyde/kg meat (Watts, 1962) for all the samples for the two seasons. Tarladgis*et al*. (1960) also reported that the minimum threshold value of TBA number of cooked meat products during storage was 0.5 – 1.0mg as detected by a trained panel. This suggests that the use of clove at 0.2% level improves the quality of "Denderu" produced at dry and rainy seasons. There is significant difference ($P< 0.05$) in TBA between the samples stored during rainy and dry seasons. There is also significant difference ($P< 0.05$) between samples in week zero and subsequent weeks of storage of the samples, which is in agreement with the findings of malav*et al.* (2013).

Peroxide Value of the "Denderu" Samples Produced During Rainy and Dry Seasons

Table 4.5 shows the result of the peroxide analysis for the period of storage of the product. The peroxide values increased with storage time. For the zero week, the peroxide values were 0.73, 0.75, 0.77, 0.71 and 0.84 milliequivalent/kg for samples SCA, CLA, SCB, SCC and LCS, respectively; at the end of three weeks of storage sample LCS had the highest value of 2.65 meq/kg while sample SCC had the least value of 2.33 meq/kg.

For samples produced during dry season, the values for the zero week were 0.85, 0.91, 0.86, 0.83 and 0.87 meq/kg sample, for samples SCA, CLA, SCB, SCC and LCS, respectively. As the storage time increased, the peroxide value increased up to the third week of storage. At the end of the third week, the peroxide values were found to be 3.61, 3.62, 3.53, 3.51 and 3.82 meg/kg for samples SCA, CLA, SCB, SCC and LCS, respectively.

The initial peroxide value for the samples produced during rainy season in the zero week ranged from 0.71 – 0.84 milliequivalent/kg. The peroxide value gradually increased throughout the three week storage period. Apart from sample SCA there was significant difference ($P< 0.05$) between the control sample and the treated samples. At week three the peroxide values were 2.61, 2.52, 2.38, 2.33 and 2.65 meq/kg for samples SCA, CLA, SCB, SCC and LCS, respectively. For the samples that were produced during the dry season, the peroxide values in the zero week were 0.85, 0.91, 0.86, 0.83 and 0.87 meq/kg for samples SCA, CLA, SCB, SCC and LCS, respectively. The values increased with increase in storage time irrespective of the treatments. At the end of the third week, the control sample was found to be significantly different ($P< 0.05$) from other treatments with 3.61, 3.62, 3.53, 3.51 and 3.82 meq/kg for samples SCA, CLA, SCB, SCC and LCS, respectively. It was observed that the peroxide values of the samples did not exceed the maximum limit recommended by Codex Standard (1999) (max 10.0 milleq of active O_2/kg). Nutritionists and buyers had arbitrarily established maximum peroxide level of between 5 – 10 meqO_2/kg of fat (Hamilton and Kirestein, 2008). The above findings are similar to the findings of Presswood (2012) where dehydrated beef strips were stored in two types of packaging material. There is significant difference ($P< 0.05$) in peroxide values between the samples stored during rainy and dry seasons. There is also significant difference ($P< 0.05$) between samples in week zero and subsequent weeks of storage of the samples.Lipid oxidation is often responsible for quality loss via formation of rancid flavour (Asghar*et al.*, 1988) and is affected by the duration and temperature of storage of meat (Sun *et al.*, 2002).

CONCLUSION

"Denderu" from raw beef treated with sodium citrate was Produced. Five (5.0) kg of beef was obtained from Wudil market and divided into five portions. Four portions were treated by dipping for one hour in 0.2% clove (CLA), 0.2% sodium citrate (SCA), 0.2% clove and sodium citrate (SCB) and another in a combination of 0.25% of sodium citrate and clove (SCC), and the remaining portion served as the control (LCS). The effect of production period (dry or rainy season) on the chemical qualities of the product during ambient storage at the rainy and dry seasons were determined. The chemical analysis conducted include: pH, Free fatty acid, Thiobarbituric acid and Peroxide value. Storage of "denderu" samples is better during dry season because of low humidity and higher temperature.

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Table 1 Experimental Design

Sample / Treatment	0.25% SC	0.25% C	0.2% SC	0.2% C
SCA			+	
CLA				+
SCB			+	+
SCC	+	+		
LCS				

Note: SC = Sodium Citrate C = Clove

Table 2 Effects of Sodium citrate on pH values of Denderu produced during rainy and dry seasons and stored for a period of three weeks.

Season	Storage (Weeks)	Sample				
		SCA	CLA	SCB	SCC	LCS
Rain	0	6.49 ± 0.01^{ct}	6.52 ± 0.02^{cs}	6.70 ± 0.00^{au}	6.15 ± 0.01^{dv}	6.63 ± 0.01^{bs}
	1	6.14 ± 0.03^{bv}	6.15 ± 0.01^{bu}	6.23 ± 0.01^{av}	5.88 ± 0.03^{cu}	6.11 ± 0.01^{bv}
	2	7.18 ± 0.01^{abr}	7.21 ± 0.01^{ar}	7.03 ± 0.01^{cr}	6.34 ± 0.01^{dr}	7.13 ± 0.00^{br}
	3	7.44 ± 0.02^{bq}	7.55 ± 0.01^{aq}	7.43 ± 0.02^{bq}	6.93 ± 0.01^{dq}	7.33 ± 0.01^{cq}
Dry	0	6.89 ± 0.01^{bs}	6.52 ± 0.01^{cs}	6.96 ± 0.04^{as}	6.19 ± 0.01^{dt}	6.13 ± 0.01^{ev}
	1	6.29 ± 0.00^{du}	6.50 ± 0.02^{cs}	6.78 ± 0.02^{bt}	6.92 ± 0.01^{aq}	6.31 ± 0.02^{dt}
	2	6.31 ± 0.01^{bu}	6.50 ± 0.01^{as}	6.24 ± 0.01^{cv}	6.24 ± 0.02^{cs}	6.27 ± 0.01^{bcu}
	3	6.29 ± 0.01^{bu}	6.35 ± 0.03^{at}	6.14 ± 0.01^{dw}	6.21 ± 0.03^{ct}	6.27 ± 0.01^{bu}

Values are means of three determinations ± standard deviation.
a,b,c,d,e Means in a row with similar letters are not significantly different (p>0.05)
q,r,s,t, u,v,w,x Means in a column with similar letters are not significantly different (p>0.05)

Key SCA = Sample treated with 0.2% sodium citrate
CLA = Sample treated with 0.2% clove
SCB = Sample treated with 0.2% clove and 0.2% sodium citrate
SCC = Sample treated with 0.25% clove and 0.25% sodium citrate
LCS = Untreated sample.

Table 3 Effects of Sodium citrate on free fatty acid of Denderu produced during rainy and dry seasons andstored for a period of three weeks. (Meq/kg)

Season	Storage (Weeks)	Sample				
		SCA	CLA	SCB	SCC	LCS
Rain	0	0.286 ± 0.001^{aw}	0.097 ± 0.001^{dw}	0.115 ± 0.000^{cdw}	0.207 ± 0.003^{bv}	0.115 ± 0.000^{cdx}
	1	0.312 ± 0.000^{bv}	0.097 ± 0.004^{ew}	0.223 ± 0.004^{cv}	0.397 ± 0.001^{at}	0.127 ± 0.001^{dw}
	2	0.511 ± 0.001^{bt}	0.173 ± 0.003^{du}	0.311 ± 0.001^{cu}	0.701 ± 0.002^{ar}	0.318 ± 0.001^{cu}
	3	0.689 ± 0.000^{bs}	0.321 ± 0.021^{et}	0.476 ± 0.004^{ds}	0.957 ± 0.001^{aq}	0.506 ± 0.000^{ct}
Dry	0	0.112 ± 0.01^{ax}	0.168 ± 0.02^{av}	0.113 ± 0.001^{ax}	0.141 ± 0.00^{ax}	0.199 ± 0.02^{av}
	1	0.502 ± 0.01^{au}	0.324 ± 0.01^{bs}	0.324 ± 0.02^{bt}	0.201 ± 0.01^{cw}	0.522 ± 0.01^{as}
	2	1.213 ± 0.01^{ar}	0.822 ± 0.01^{cr}	0.611 ± 0.02^{dr}	0.352 ± 0.01^{eu}	1.096 ± 0.011^{br}
	3	2.810 ± 0.02^{bq}	2.155 ± 0.03^{cq}	1.039 ± 0.04^{dq}	0.563 ± 0.01^{es}	2.970 ± 0.03^{aq}

Values are means of three determinations ± standard deviation.
a,b,c,d,e Means in a row with similar letters are not significantly different (p>0.05)
q,r,s,t, u,v,w,x Means in a column with similar letters are not significantly different (p>0.05)
Key SCA = Sample treated with 0.2% sodium citrate
CLA = Sample treated with 0.2% clove
SCB = Sample treated with 0.2% clove and 0.2% sodium citrate
SCC = Sample treated with 0.25% clove and 0.25% sodium citrate
LCS = Untreated sample.

Table 4 Effects of Sodium citrate on TBA values of Denderu produced during rainy and dry seasons and stored for a period of three weeks (Mg malonaldehyde/Kg)

Season	Storage (Weeks)	Sample				
		SCA	CLA	SCB	SCC	LCS
Rain	0	0.018 ± 0.001^{cx}	0.022 ± 0.002^{bcw}	0.029 ± 0.004^{abw}	0.032 ± 0.001^{au}	0.032 ± 0.003^{aw}
	1	0.027 ± 0.003^{cv}	0.037 ± 0.001^{bu}	0.053 ± 0.001^{at}	0.055 ± 0.004^{as}	0.055 ± 0.002^{at}
	2	0.032 ± 0.001^{du}	0.052 ± 0.002^{cs}	0.136 ± 0.001^{ar}	0.086 ± 0.001^{cr}	0.314 ± 0.003^{br}
	3	0.070 ± 0.004^{eq}	0.094 ± 0.011^{dq}	0.182 ± 0.001^{cq}	0.252 ± 0.000^{bq}	0.522 ± 0.002^{aq}
Dry	0	0.021 ± 0.001^{bw}	0.023 ± 0.004^{bw}	0.026 ± 0.001^{abx}	0.019 ± 0.001^{bw}	0.033 ± 0.004^{aw}
	1	0.041 ± 0.001^{at}	0.035 ± 0.001^{abv}	0.032 ± 0.003^{bv}	0.024 ± 0.001^{cv}	0.038 ± 0.004^{abv}
	2	0.053 ± 0.002^{as}	0.048 ± 0.001^{abt}	0.042 ± 0.002^{bu}	0.044 ± 0.001^{abt}	0.051 ± 0.001^{au}
	3	0.062 ± 0.003^{abcr}	0.056 ± 0.000^{cr}	0.066 ± 0.001^{abs}	0.057 ± 0.004^{bcs}	0.067 ± 0.003^{as}

Values are means of three determinations ± standard deviation.
a,b,c,d,e Means in a row with similar letters are not significantly different (p>0.05)
q,r,s,t, u,v,w,x Means in a column with similar letters are not significantly different (p>0.05)

Key SCA = Sample treated with 0.2% sodium citrate
CLA = Sample treated with 0.2% clove
SCB = Sample treated with 0.2% clove and 0.2% sodium citrate
SCC = Sample treated with 0.25% clove and 0.25% sodium citrate
LCS = Untreated sample.

Table 5 Effects of Sodium citrate on Peroxide values (Meq/Kg) of Denderu produced during rainy and dry seasons and stored for a period of three weeks

Season	Storage (Weeks)	Sample				
		SCA	CLA	SCB	SCC	LCS
Rain	0	0.73 ± 0.01^{bcx}	0.75 ± 0.01^{bcw}	0.77 ± 0.01^{bx}	0.71 ± 0.01^{cx}	0.84 ± 0.01^{ax}
	1	1.13 ± 0.01^{abv}	1.16 ± 0.01^{au}	1.04 ± 0.01^{cdv}	1.01 ± 0.01^{dv}	1.09 ± 0.01^{bcv}
	2	1.97 ± 0.02^{at}	1.83 ± 0.01^{bs}	1.73 ± 0.02^{ct}	1.68 ± 0.01^{dt}	1.93 ± 0.01^{at}
	3	2.61 ± 0.04^{ar}	2.52 ± 0.00^{br}	2.38 ± 0.01^{cx}	2.33 ± 0.02^{cs}	2.65 ± 0.04^{as}
Dry	0	0.85 ± 0.01^{abw}	0.91 ± 0.02^{av}	0.86 ± 0.01^{abw}	0.83 ± 0.01^{bw}	0.87 ± 0.00^{abw}
	1	1.25 ± 0.01^{du}	1.32 ± 0.03^{bct}	1.47 ± 0.02^{au}	1.28 ± 0.01^{cdu}	1.37 ± 0.01^{bu}
	2	2.32 ± 0.03^{es}	2.53 ± 0.01^{dr}	2.61 ± 0.01^{cr}	2.91 ± 0.01^{ar}	2.71 ± 0.01^{br}
	3	3.61 ± 0.01^{bq}	3.62 ± 0.02^{bq}	3.53 ± 0.01^{cq}	3.51 ± 0.02^{cq}	3.82 ± 0.03^{aq}

Values are means of three determinations ± standard deviation.
a,b,c,d,e Means in a row with similar letters are not significantly different ($p>0.05$)
q,r,s,t, u,v,w,x Means in a column with similar letters are not significantly different ($p>0.05$)

Key SCA = Sample treated with 0.2% sodium citrate
CLA = Sample treated with 0.2% clove
SCB = Sample treated with 0.2% clove and 0.2% sodium citrate
SCC = Sample treated with 0.25% clove and 0.25% sodium citrate
LCS = Untreated sample.

Plate 1: "Denderu" Samples after Production